DC-Operated Stepper Motors

With unidirectional rotation and slow speed

By A. Schilp

This circuit has been designed specifically to allow a small stepper motor to rotate in one direction at a very slow speed. The main application is in the area of model making.

A circuit like the one described here can be very useful when little power and slow speeds are required, but a gearbox is undesirable. Some applications to consider are a radar antenna on a model ship, which rotates at about 30 times per minute, or the vanes of a windmill as part of a model railway, which turns at no more than about 20 revolutions per minute. The driver circuit described here provides a speed from about 5 to 100 rpm and is therefore ideal for these types of applications.

(Photo: courtesy Kenteq)

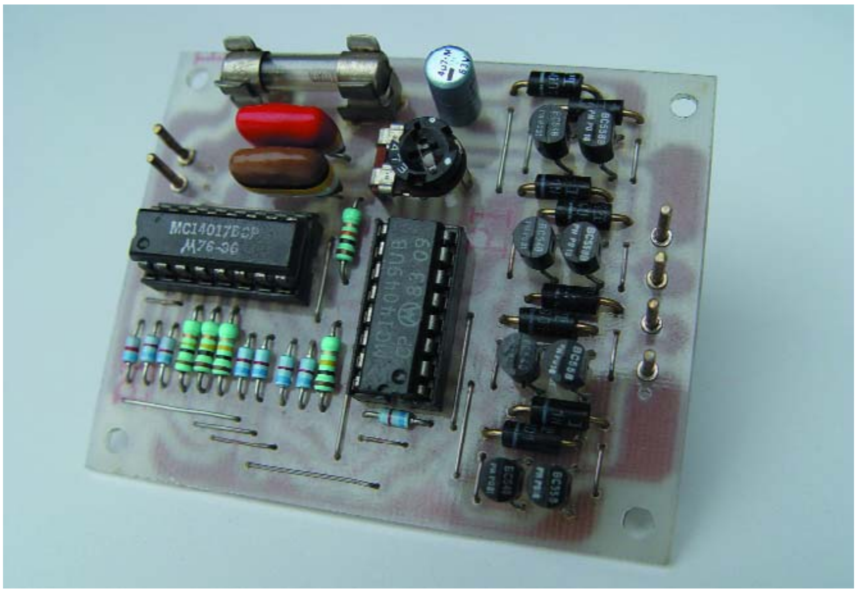
Step size

In practice, stepper motors are not usually intended for rotating applications, but are used for positioning. A stepper motor doesn't actually rotate in the usual sense; it makes small steps instead. You have to take into account the specification for power supply of the windings and the number of degrees per step. When the step angle is greater than 1.8 degrees, that is, less than 200 steps per revolution, the individual steps can almost always be discerned and a smooth, slow turning motion cannot be realised with this circuit. The best results will be obtained with a stepper motor with a step angle of 0.9 degrees, that is, 400 steps per revolution. Higher steps per revolution are rare in practice.

Schematic

As can be seen from the schematic shown in **Figure 1**, the complete driver circuits consists of little more than two ICs and eight transistors. There are no 'difficult' parts, they are all, without exception, standard components.

The rotational speed of the stepper motor is determined by the position of P1, which adjusts the frequency of the clock pulse generator consisting of IC1d, IC1e, R5, P1 and



C3. The value of C3 may be changed to suit, but above 100 revolutions per minute, most stepping motors will refuse to cooperate. There is no minimum speed.

The clock pulse is routed to the clock input (pin 13) of IC2. This is a decade counter of the type 4017, which has been configured so that at each clock pulse, one of the outputs Q0 (pin 3) through to Q7 (pin 6) goes high in succession. Once Q7 has been 'high', the counter resets itself and the cycle repeats. The truth table shown in **Figure 2** illustrates the operation.

R1 through to R4 and D9 through to D16 form a matrix that converts the eight sequential states of the counter to driver signals for the winding terminals A, B, C and D. The truth table lists the voltage potentials at the winding terminals, as well as the resulting coil voltages U_{AB} and U_{CD}.

The drivers consist of T1 through T8, D1 through D8 and IC1a to IC1d at the coil ends A, B, C and D. The ends of the windings are connected to either power or ground, depending on the logic level at the input of the inverter. It is self-evident that the voltage across the winding is equal to zero when both ends are connected to the same power supply rail.

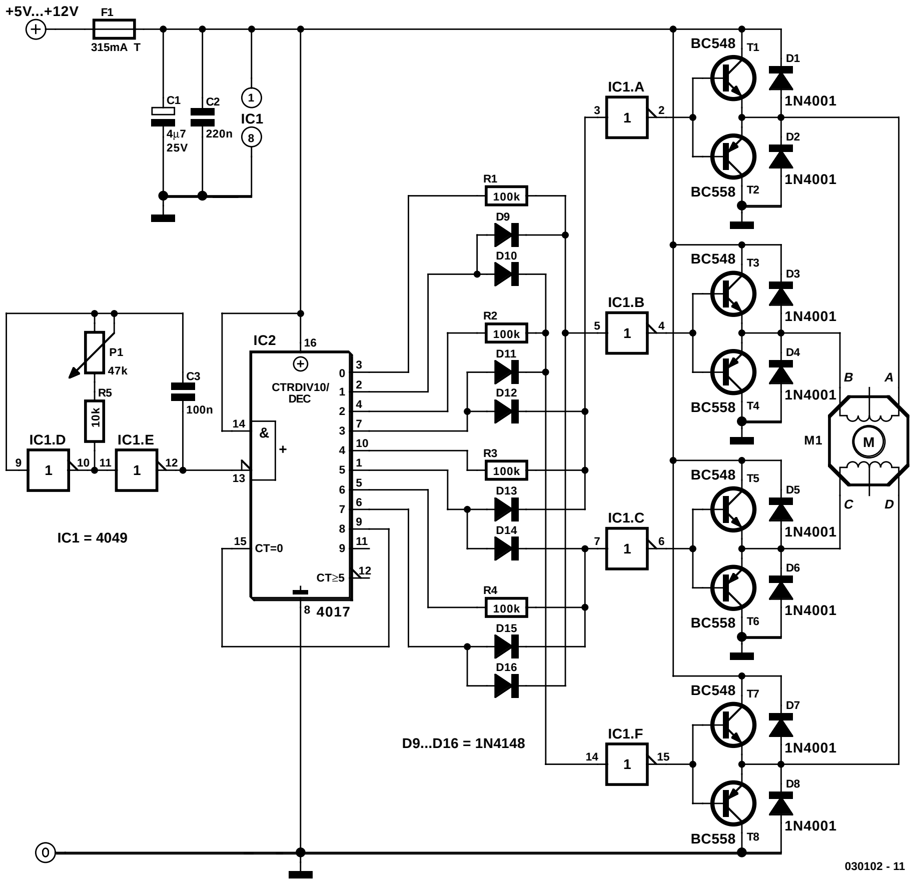


Figure 1. The driver circuit comprises very few parts.

CLK IC2 ⌀13	Q0 IC2 ⌀3	Q1 IC2 ⌀2	Q2 IC2 ⌀4	Q3 IC2 ⌀7	Q4 IC2 ⌀10	Q5 IC2 ⌀1	Q6 IC2 ⌀5	Q7 IC2 ⌀6	A	B	C	D	U_{AB}	U_{CD}
0	1	0	0	0	0	0	0	0	+V	GND	+V	+V	↑	
1	0	1	0	0	0	0	0	0	+V	GND	+V	GND	↑	↓
2	0	0	1	0	0	0	0	0	+V	+V	+V	GND		↓
3	0	0	0	1	0	0	0	0	GND	+V	+V	GND	↓	↓
4	0	0	0	0	1	0	0	0	GND	+V	+V	+V	↓	
5	0	0	0	0	0	1	0	0	GND	+V	GND	+V	↓	↑
6	0	0	0	0	0	0	1	0	+V	+V	GND	+V		↑
7	0	0	0	0	0	0	0	1	+V	GND	GND	+V	↑	↑

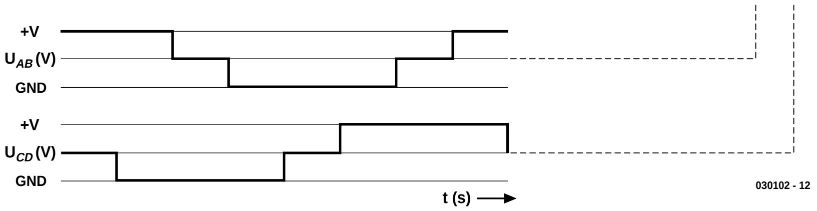


Figure 2. This truth table illustrates the operation of the stepper motor driver.

Remarks

Many stepper motors have windings with a centre tap. This connection must be left open because it is not used with this bipolar drive circuit. Implementations without centre taps can be recognised from the fact that they only have four connecting wires. Designs with centre tap have five or six wires. Note that motors with five wires are not suitable for this application, because the centre taps have been connected internally.

The circuit described here is intended for the smallest possible stepper motor and the lowest possible supply voltage. The larger the motor and the higher the power supply voltage, the more work the driver transistors T1 through T8 have to do. Fuse F1 limits the current through the transistors and diodes. If the drivers have to switch higher currents, then it is desirable to replace T1, T3, T5 and T7 with the Darlington transistor BD677 and use its complement, the BD678, to replace T2, T4, T6 and T8. These transistors possess integrated avalanche diodes, so diodes D1 through D8 may be omitted.

The author has designed a simple PCB for the circuit. The layout is unfortunately not available, but considering the simplicity, the driver circuit can also be easily built on a piece of prototyping board.

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